

PRODUCTION PERFORMANCE OF COTTON IN NORTH INDIA: A STATE LEVEL ANALYSIS

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ABSTRACT

Cotton is a significant commercial fibre crop. It is one of the most important cash crops in the Indian economy. The current study attempts to understand the growth rates and variability in area, production, and productivity of cotton crop in India's north cotton zone using the secondary data for the period of 40 years (from 1980-81 to 2019-20). Results revealed that during the last 4 decades, area under cotton was found to be decreased in Punjab whereas in Haryana and Rajasthan there was significant increase in area under cotton. The annual growth rate of area under cotton was found to be reducing significantly in Punjab (-1.90%) whereas in Haryana (3.54%) and Rajasthan (5.79%), it was increasing significantly. On the other side, productivity has shown a significant increase of 1.70 per cent, 1.43 per cent and 2.43 per cent in Punjab, Haryana and Rajasthan, respectively. In the case of cotton higher variability in productivity and production was observed in comparison to wheat and paddy. Highest instability in production was observed in Rajasthan (40.86%) followed by Punjab (34.29%) and Haryana (22.33%). whereas at national level it was 21.86 per cent. As far as productivity is concerned, highest variability was observed in Rajasthan (29.73%), followed by Punjab (29.53%) and Haryana (24.19%). The area and productivity in Punjab affected the cotton production negatively but in Haryana and Rajasthan it was observed positive.

Keywords: Cotton, CAGR, Decomposition Analysis, North zone, Production, Variability

Cotton is a perennial shrub that has been cultivated by humans for thousands of years and is sometimes referred to as 'White Gold'. In India, it is a valuable cash crop. Cotton is grown in India and Africa as well as other parts of the world. The domestication of the cotton crop for the purpose of obtaining fibre to produce garments could be seen as the first step towards its commercial utilization. During 2019-20, India had the distinction of having the largest area under cotton cultivation (13.37 million hectares), accounting for around 41.5 percent of the global area under cotton cultivation (Govt. of India, 2020). India is one of the world's top cotton producers, accounting for roughly 22.5 percent of global cotton production. The seed cotton output in India, at 1157 kg/ha, is still lower than the global average yield of around 2137 kg/ha (www.fao.org). Cotton is cultivated across the country and its area is classified into three zones: Northern (Punjab, Haryana, and Rajasthan), Central (Gujarat, Maharashtra, and Madhya Pradesh), and Southern (Andhra Pradesh, Tamil Nadu and Karnataka).

Punjab, Haryana, and Rajasthan form India's cotton belt in the North Zone. Cotton is grown in irrigated regions of the northern zone from mid-April to the last week of May. Planting begins in the central and southern zones in June-July, depending on the beginning of monsoon, and continues until August. In Tamil Nadu (Southern

Zone). The summer crop planting begins in January-February and winter crop planting begins in June-July. Harvesting is mostly limited to the months of October through February across the country. From 12.42 per cent of total cotton area, the north zone produces 15.14 per cent of the country's total cotton production. The central zone accounts for 55 per cent of India's total cotton production (Govt. of India, 2020).

In 2019-20, area under cotton crop in Punjab was 248 thousand ha and total production of cotton was 1222 thousand bales with the average yield of 827 kg/ha (Govt. of Punjab, 2020). The major cotton growing districts in Punjab are Bathinda, Fazilka, Mansa and Sri Muktsar Sahib. These districts cover 97.35 per cent area and 98.05 per cent of production of cotton in the state. During 2019-20, area under cotton in Rajasthan was 760 thousand ha, production was 2787 thousand bales with an average yield of 623 kg/ha. Sri Ganganagar, Hanumangarh, Alwar and Nagaur are the major cotton growing districts which account for about 70.43 per cent of total production of cotton in the Rajasthan state (Govt. of Rajasthan 2020). The area under cotton in Haryana was 723 thousand ha, production was 2484 thousand bales with the average yield of 584 kg/ha during 2019-20. Hissar, Sirsa, Bhiwani, Fatehabad, Jind are the major cotton producing districts of the state (Govt. of Haryana 2020). These districts cover 80 per cent area and 81.65 per cent of production of cotton in the state. The present study was carried out to compare

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the performance of cotton cultivation in different cotton growing states of North India.

MATERIALS AND METHODS

The study was conducted in northern cotton growing states of India namely, Punjab, Haryana and Rajasthan. The time series secondary data (1980-81 to 2019-20) regarding area, production and productivity of cotton in Punjab, Haryana, Rajasthan as well as India were collected from various published sources such as Statistical Abstract of Punjab, Statistical Abstract of Haryana, Statistical Abstract of Rajasthan, Agricultural Statistics at a Glance as well as websites like www.indiastat.com, www.agriculture.rajasthan.gov.in, www.esaharyana.gov.in, etc. Compound annual growth rates (CAGRs) and coefficient of variation (CV) of area, production and productivity were worked out for each state under study. Decomposition analysis of growth in production of cotton in different decades was undertaken to study the area, productivity and their interaction effects.

Growth analysis

The compound annual growth rates (CAGR's) of production trends of cotton were estimated for the cotton growing states of north India (Punjab, Haryana and Rajasthan) as well as for India for the last four decades viz; Period I (1980-81 to 1989-90), Period II (1990-91 to 1999-2000), Period III (2000-01 to 2009-10), Period IV (2010-11 to 2019-20) and overall time-period (1980-81 to 2019-20), respectively.

The following growth model has been used:

$$Y_t = AB^t$$

Where, Y_t = Area/production/productivity of cotton for the year 't'.

t = Time variable (1, 2, 3,....., n) for each period

A = Constant

B = Growth coefficient

Log transformation of above model is as under:

$$\ln Y_t = \ln A + t (\ln B).$$

Where, $\ln B = \ln (1+r)$, and

$$t = [\text{antilog} (\ln B) - 1]$$

$$\text{CAGR's (\%)} = [\text{antilog} (\ln B) - 1] \times 100$$

Student's-test was used to test the significance CAGR's.

Variability in area, productivity and production of cotton

The Cuddy Della Valle Index was used to examine the variability in area, productivity, and production of cotton in relative terms (Weber and Sievers, 1985;

Singh and Byerlee, 1990). In time series data with long-term trends, the simple coefficient of variation overestimates the level of instability. The Cuddy Della Valle Index corrects the coefficient of variation. This index was worked out using the following formula:

$$CV^* = CV \times (1-R^2)^{0.5}$$

CV* stands for the Cuddy Della Valle Index, which is the corrected coefficient of variation (CV). Henceforth, any mention of CV* would refer to the Cuddy Della Valle Index. CV is the simple estimate of the coefficient of variation (in per cent), and R^2 is the coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom."

Decomposition analysis of growth in production

To measure the relative contribution of area and productivity to the total change in cotton production, the decomposition analysis model was used. Cotton production was decomposed in three components: area, productivity and their interaction effect, respectively. The following additive decomposition scheme was used:

$$\Delta P = \Delta A Y_0 + \Delta Y A_0 + \Delta A \Delta Y$$

Change in production = Area effect + Productivity effect + Interaction effect

$$1 = \frac{(A_n - A_0) Y_0}{P_n - P_0} + \frac{(Y_n - Y_0) A_0}{P_n - P_0} + \frac{(Y_n - Y_0) (A_n - A_0)}{P_n - P_0}$$

Where;

$\Delta P = (P_n - P_0)$: Change in cotton production between two points of time

$\Delta A = (A_n - A_0)$: Change in area under cotton between two points of time

$\Delta Y = (Y_n - Y_0)$: Change in average productivity of cotton between two points of time

A_0 : Area under cotton crop in the base year

A_n : Area under cotton crop in the n^{th} year

Y_0 : Average productivity of cotton crop in the base year

Y_n : Average productivity of cotton crop in the n^{th} year

$\Delta A Y_0$: Area effect

$\Delta Y A_0$: Productivity effect

$\Delta A \Delta Y$: Interaction effect of area and productivity

RESULTS AND DISCUSSION

Overtime scenario of area, production and productivity of cotton in north India

The analysis of data revealed that during TE 1982-

83 to TE 1989-90, the cotton area increased by 2.57 per cent in Punjab and 26.61 per cent in Haryana, while in Rajasthan it decreased by 4.86 per cent (Table 1). The introduction of short duration high yielding cotton hybrids was the main reason for the increase in area in Punjab and Haryana. Due to the onslaught of the American ball worm in Rajasthan during this decade, cotton productivity remained at just 108 kg/ha. This was the major cause of the decline in area in Rajasthan. At the national level, the cotton area decreased by 9.44 per cent during the same time period. During the following decade (TE 1992-93 to TE 1999-2000), area in Punjab decreased by 11.71 per cent due to the attack by American ball worm, whereas the area under cotton in the other two states increased. The highest increase was observed in Rajasthan (27.45%) due to rise in productivity in the preceding years, but during this period the productivity started declining. Consequently, the area under cotton witnessed a decline in subsequent years. Between TE 2012-13 to TE 2019-20, there was a 44.62 per cent decline in area under cotton in Punjab, which was the highest decline during the study period under consideration. This was due to cotton being shifted by paddy due to whitefly attack, but in Haryana and Rajasthan change was reciprocal owing to lack of substitutes. At the overall level (TE 1982-83 to TE 2019-

20), the area under cotton in Punjab has continuously decreased, but it has increased in Haryana and Rajasthan. At national level, it likewise demonstrated an upward tendency.

Punjab experienced a 75.37 and 70.69 per cent increase in production and productivity during TE 1982-83 and TE 1989-90, respectively. In Haryana, the production was increasing while yield had declined by 1.79 per cent. In Rajasthan, the production and productivity increased by 31.97 and 35.79 per cent, respectively. During TE 1992-93 to TE 1999-2000, the decline in area under crop in Punjab had led to decline in production by 61.01 per cent. The decline was also noticed in the North Indian belt as a whole and at the national level in terms of production and yield. The period of TE 2002-03 to TE 2009-10 has shown progressive results in terms of both production and yield due to the introduction of new varieties and awareness amongst the farmers. Rajasthan has shown the highest increase in production as well as in yield by 100.64 and 106.46 per cent in comparison to the other two states under study. Over a 40-year period (TE 1982-83 to TE 2019-20), production and yield have remained positive, indicating that crop production has increased despite varying trends.

Table 1. Change in area, production and productivity of cotton in north India, 1980-81 to 2019-20

(Per cent)

States	Period				
	I (TE1982-83 to TE1989-90)	II (TE1992-93 to TE1999-00)	III (TE2002-03 to TE2009-10)	IV (TE2012-13 to TE2019-20)	Overall (TE1982-83 to TE2019-20)
Change in area					
Punjab	2.57	-11.71	8.88	-44.62	-61.24
Haryana	26.61	10.04	-13.68	25.09	101.63
Rajasthan	-4.86	27.45	-9.94	32.84	74.18
North India	6.5	6.51	-4.93	5.76	15.03
India	-9.44	19.52	18.66	7.09	62.84
Change in production					
Punjab	75.37	-61.01	71.79	-21.93	0.76
Haryana	25.25	-14.79	79.12	-5.05	183.09
Rajasthan	31.97	0.89	100.64	59.09	404.97
North India	52.05	-34.27	78.92	7.71	132.31
India	18.59	8.85	123.13	-7.99	332.1
Change in productivity					
Punjab	70.69	-54.01	55.11	40.42	158.95
Haryana	-1.79	-22.34	102.46	-16.97	52.38
Rajasthan	35.79	-20.69	106.46	11.03	180.00
North India	41.49	-37.4	82.93	1.41	101.32
India	29.52	-8.88	86.11	-14.19	165.28

Growth in area, production, and productivity

The growth of the cotton crop in terms of acreage, production, and productivity over a period of 40 years is given in Table 2. It was revealed that its area in Punjab grew at a negligible pace during Period I. Production and productivity, on the other hand, improved dramatically by 9.54 and 9.01 per cent each year, respectively. Haryana's annual growth in area and production was 3.47 and 4.63 per cent, respectively. Similarly, in Rajasthan, the cotton production increased significantly (4.19%) during the same period. During period II, at national level, the cotton area and production both increased by 2.71 and 2.29 per cent, respectively. The cotton area in Rajasthan and Haryana, cotton area increased by 4.22 and 2.07 per cent, respectively. Whereas in north cotton zone of India area under cotton was decreased by 2.53 per cent. During this decade in Punjab, the production declined significantly at the rate of 11.48 per cent per annum-which happened due to the attack of American bollworm. Due to instability in cotton productivity, farmers of the state shifted to other crops. However, in Haryana and Rajasthan, the cotton area increased significantly at the rate of 3.54 and 5.79 per cent per annum, respectively. During overall period of

40 years, area under cotton in Punjab reduced by 1.90 per cent per annum although productivity has increased significantly at the rate of 1.70 per cent per annum. In other states as well as at national level, the area, production, and productivity grew significantly during the same period.

Instability in area, production and productivity of cotton in North India

The results related to instability in area, production and productivity of cotton in North India are given in Table 3. Cotton area showed highest variability in Punjab state (13.16%) during period I followed by Haryana (10.24%) and Rajasthan (9.20%) and similar trend was observed in period II. During period III, the highest variation in area was observed in Rajasthan (14.42%) followed by Punjab (10.41%) and Haryana (7.89%). During period IV, highest variability in area was noticed in Rajasthan (17.45%) followed by Haryana (7.94%) and Punjab (7.09%). During the overall period of 40 years, Rajasthan had shown substantial variability in area under cotton (22.76%) followed by Punjab and Haryana with 16.53 and 13.85 per cent, respectively. At the national level, it was much lower (9.99%) than that

Table 2. Growth in area, production, and productivity in north India, 1980-81 to 2019-20

(CAGR in per cent)

States	Period				
	I (1980-81 to 1989-90)	II (1990-91 to 1999-00)	III (2000-01 to 2009-10)	IV (2010-11 to 2019-20)	Overall (1980-81 to 2019-20)
Area					
Punjab	0.48 ^{NS}	-2.43 ^{NS}	1.30 ^{NS}	-8.64 ^{***}	-1.90 ^{***}
Haryana	3.47 ^{***}	2.07 ^{**}	-2.08 ^{**}	3.54 ^{***}	1.39 ^{***}
Rajasthan	-0.60 ^{NS}	4.22 ^{***}	-2.98 [*]	5.79 ^{**}	0.68 ^{**}
North India	6.07 ^{***}	-2.53 ^{**}	2.69 ^{**}	3.72 ^{**}	2.38 ^{***}
India	-1.24 ^{**}	2.71 ^{***}	2.03 ^{**}	1.09 [*]	1.51 ^{***}
Production					
Punjab	9.54 ^{***}	-11.48 ^{***}	9.08 ^{***}	-5.12 ^{NS}	-0.22 ^{NS}
Haryana	4.63 ^{**}	-1.35 ^{NS}	8.21 ^{***}	-0.03 ^{NS}	1.62 ^{***}
Rajasthan	4.19 ^{**}	1.18 ^{NS}	8.94 [*]	9.12 ^{***}	2.43 ^{***}
North India	7.27 ^{***}	-4.78 ^{**}	8.43 ^{***}	1.31 ^{NS}	1.81 ^{***}
India	2.81 ^{NS}	2.29 ^{**}	13.60 ^{***}	-0.87 ^{NS}	4.74 ^{***}
Productivity					
Punjab	9.01 ^{***}	-9.27 ^{***}	7.66 ^{***}	3.77 ^{NS}	1.70 ^{***}
Haryana	1.11 ^{NS}	-3.34 [*]	10.50 ^{***}	-2.73 ^{NS}	1.62 ^{***}
Rajasthan	4.85 ^{NS}	-2.91 [*]	12.23 ^{**}	2.52 ^{***}	2.43 ^{***}
North India	-1.38 ^{NS}	-2.36 ^{NS}	5.38 ^{**}	-4.36 ^{NS}	-0.75 ^{**}
India	4.11 ^{***}	-0.38 ^{NS}	11.34 ^{***}	-1.93 ^{**}	3.17 ^{***}

***, ** and *: Statistically significant at 1, 5 and 10 per cent probability level, respectively.

CAGR: Compound annual growth rate

Table 3. Variability in area, production and productivity of cotton in north India, 1980-81 to 2019-20

(CV in per cent)

States	Period				
	I (1980-81 to 1989-90)	II (1990-91 to 1999-00)	III (2000-01 to 2009-10)	IV (2010-11 to 2019-20)	Overall (1980-81 to 2019-20)
Area					
Punjab	13.16	11.66	10.41	7.09	16.53
Haryana	10.24	7.50	7.89	7.94	13.85
Rajasthan	9.20	7.07	14.42	17.45	22.76
North India	6.47	9.22	8.99	13.99	17.82
India	4.92	6.69	7.20	3.19	9.99
Production					
Punjab	20.42	22.30	17.08	25.93	34.29
Haryana	17.06	13.39	18.21	22.19	22.33
Rajasthan	0.86	18.57	26.79	18.57	40.86
North India	16.11	16.53	16.31	19.44	22.96
India	15.84	4.08	33.76	5.99	21.86
Productivity					
Punjab	19.17	20.46	13.45	27.08	29.53
Haryana	14.77	13.64	18.77	18.58	24.19
Rajasthan	29.15	14.02	26.23	6.72	29.73
North India	13.88	18.53	16.55	23.47	23.53
India	11.54	3.35	24.41	8.82	26.25

CV indicates Cuddy Della Valle index

in the northern states.

Variability in terms of production under cotton underlined that it was highest in Punjab comprising a percentage of 20.42, followed by Haryana (17.06) and Rajasthan (0.86%) during period I. Same was the case in period II. During period III, the results were in contrast for Rajasthan, as it became the major state as far as instability in production was concerned followed by Haryana and Punjab, comprising the percentage of 26.79, 18.21 and 17.08 per cent, respectively. During the overall period of 40 years (period V), production instability was highest in Rajasthan (40.86%) followed by Punjab (34.29%) and Haryana (22.33%). In the North India level, it was 22.96 per cent. The scenario of production variability amongst the states was quite fluctuating from one period to another due to incidence of various pests and diseases which severely affected the cotton production.

Instability in cotton productivity showed that during period I, it was highest in Rajasthan with percentage of 29.15, followed by Punjab and Haryana with respective percentages of 19.17 and 14.77. During period II, variability in production was highest in Punjab with percentage of 20.46 and lowest in India with percentage

of 3.35 per cent. During the overall period of four decades (period V), highest variability in productivity was observed in Rajasthan (29.73%), followed by Punjab (29.53%).

Decomposition analysis of cotton production in north India

The effects of area, yield and its interaction towards the change in cotton production in Punjab, Haryana, Rajasthan as well as at national level for the last four decades were worked out by using decomposition analysis (Table 4). Over the periods I, II, and III, the yield impact was a key contributor to the increase in cotton production in Punjab, accounting for 94.03, 88.28, and 84.93 per cent, respectively. While the area effect contributed 170.08 per cent to change in cotton production in Punjab during period IV, the yield effect was negative (-129.89%) due to white fly assault during that period. Over the period of 40 years, the area effect was negative (-120.00%) because variability in cotton yield due to insect pest attack at different intervals forced the farmers to shift the area devoted towards cotton to paddy. During Period I, the area effect in Haryana was 104.21 per cent, which was a significant

Table 4. Decomposition analysis of cotton production in north India, 1980-81 to 2019-20

(Per cent)

Particulars	Period				
	I (TE1982-83 to TE1989-90)	II (TE1992-93 to TE1999-00)	III (TE2002-03 to TE2009-10)	IV (TE2012-13 to TE2019-20)	Overall (TE1982-83 to TE2019-20)
Punjab					
Area effect	3.50	26.58	8.74	170.08	-120.00
Yield effect	94.03	88.28	84.93	-129.89	312.05
Interaction effect	2.47	-14.86	6.33	59.81	-92.05
Haryana					
Area effect	104.21	-100.25	-18.93	-918.11	55.52
Yield effect	-3.33	173.68	140.15	795.58	22.05
Interaction effect	-0.88	26.56	-21.22	222.53	22.43
Rajasthan					
Area effect	-43.33	-178.00	-23.02	51.27	18.30
Yield effect	150.52	133.50	154.77	35.23	46.88
Interaction effect	-7.19	44.50	-31.75	13.50	34.82
North Zone of India					
Area effect	12.63	-18.54	-11.25	77.49	11.38
Yield effect	82.03	110.97	122.76	21.03	77.03
Interaction effect	5.35	7.57	-11.51	1.48	11.58
India					
Area effect	-50.01	154.52	9.42	-165.75	18.89
Yield effect	165.64	-45.86	79.26	243.18	49.81
Interaction effect	-15.62	-8.66	11.32	22.57	31.29

factor in raising cotton production; however, the yield effect was (-3.33%), which had a negative impact but was cancelled out by the huge area effect. However, the area effect was negative during periods II, III, and IV and the yield effect was positive throughout the same periods. In the case of Rajasthan, area effect was highest in the period IV (51.27%) and lowest in the period II (-178.00%) because of decrease in yield of cotton during the preceding period, while the yield effect was positive during the study period. It was highest during period III (154.77%) and lowest (35.23%) for the period IV. In the case of North cotton zone of India the area, yield and their interaction effect were found to be positive during period I. The area effect was negative during period II (-18.54%) and period III (-11.25%) as there was decline in area under cotton in Haryana and Rajasthan during these periods. On the other hand, the cotton yield had positive impact on its production during period II (110.97%) and period III (122.76). During the overall period under study (period V) the area, yield and its interaction effect were observed to be positive. At national level, the area effect was highest during the period II (154.52%) and lowest during period IV

(-165.75%). The yield effect was highest during period IV (243.18%) lowest during period II (-45.86%). During the overall period (Period V) under study, the area, yield and its interaction effect were positive.

In conclusion, area under cotton was observed to be decreasing in Punjab, whereas in Haryana and Rajasthan there was a significant increase in area under cotton during the study period. The annual growth rate of area was found to be significantly negative in Punjab (1.90%) whereas in Haryana (3.54%) and Rajasthan (5.79%), the area was found to increase significantly. Introduction of Bt cotton led to a significant increase in cotton production by 1.70 per cent, 1.43 per cent and 2.43 per cent for Punjab, Haryana and Rajasthan, respectively. In the case of area, Rajasthan showed high variability with 22.76 per cent followed by Punjab and Haryana with 16.53 and 13.85 per cent, respectively, whereas at national level it was merely 9.99 per cent. During the last 4 decades, highest variability in productivity was observed in Rajasthan (29.73%), followed by Punjab (29.53%) and Haryana (24.19%). The infestation of the American ball worm, white fly, mealy bug, etc. were found to be the major

reasons for variability. During the last 40 years, the area and yield effect was negative in Punjab but in Haryana and Rajasthan it was positive.

Authors' contribution

Conceptualization of research work and designing of experiments(RK, MG, JS); Data collection (AS,RK); Data analysis and interpretation of results (AS, RK, MG, JS); Preparation of manuscript (AS, RK).

LITERATURE CITED

- Govt. of India 2020. *Agricultural Statistics at a Glance*. Ministry of Agriculture & Farmers Welfare, Directorate of Economics and Statistics, Government of India.
- Govt. of Haryana 2020. *Statistical Abstract of Haryana*. Economic and statistical organization of Haryana, Government of Haryana.
- Govt. of Punjab 2020. *Statistical Abstract of Punjab*. Economic and statistical organization of Punjab, Government of Punjab.

- Govt. of Rajasthan 2020. *Statistical Abstract of Rajasthan*. Economic and statistical organization of Rajasthan, Government of Rajasthan.
- Kumar R and Jaulkar A M, Srivastava S C and Singh S 2021. A study on growth and instability of paddy and wheat crops in Gwalior district (Madhya Pradesh). *The Pharma Innovation Journal* **10**: 745-48.
- Samim E and Kaur P 2020. Growth and instability of cotton production in India. *J Agril Develop Policy* **30**: 170-76.
- Sanjay S 2018. Growth and instability in cotton cultivation in Northern India. *Economic Affairs* **63**:295-85.
- Sharma S and Singh I P 2014. Growth and instability in cotton production in Rajasthan. *Agril Situ India* **70**: 15-19.
- Singh A J and Byerlee D 1990. Relative variability in wheat yields across countries and over time. *J Agril Econ* **41**: 21-32.
- Weber A and Sievers M 1985. Observations on the geography of wheat production instability. *Qtly J International Agri* **24**: 201-11.